INSTRUCTION MANUAL

LOW NOISE TUNABLE UHF PREAMPLIFIER AP-502R

MP MASTER
MA30060

ELECTRO INTERNATIONAL, INC.

INSTRUCTION MANUAL

FOR

AP-502R

PREAMPLIFIER

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ELECTRO INTERNATIONAL, INC.
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Annapolis, Maryland

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Product stored or operated under ambient conditions other than those specified.

Unauthorized modification of product.

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SECTION 1 - GENERAL INFORMATION

Figure 1-1 AP-502R Preamplifier

1-1 APPLICATION

Designed to satisfy low noise requirements in narrow-band applications, this preamplifier covers the frequency range from 300 to 1000 mc.

1-2 DESCRIPTION

The AP-502R unit is compact, featuring a solid state power supply, and low noise triodes in the VHF preamplifier section. When used with commercially available radio-frequency interference meters, this preamplifier provides an increase in sensitivity and overall improvement of the noise figure.

The preamplifier section consists of two rf stages employing tuned coaxial lines in a grounded grid triode circuit.

1-3 FEATURES

Low noise figure
High gain
Increased sensitivity
Calibrated tuning dial
Internal solid state power supply
50-ohm input impedance

1-4 SPECIFICATIONS

Frequency Range	300-1000 mc
Bandwidth	3.5 mc at 300 mc 15 mc at 1000 mc
Gain	26 db (nominal) plus or minus 3 db
Noise Figure	4 db at 300 mc 8 db at 1000 mc
Impedance (Input and Output)	50-ohm VSWR $<$ 1.2:1
Input and Output Connections	Type BNC (connections may be made at either front or rear panel)
Power	95-125 VAC, 56-66 cps, 0.52 amps
Dimensions	Rackmounting, 19" x 3-1/2" (requires 16" behind front panel)
Weight	22 lbs.

SECTION 2 - THEORY OF OPERATION

2-1 R. F. AMPLIFIER STAGES

The AP-502R UHF Preamplifier contains two electrically identical rf stages, one of which is shown schematically in figure 2-1.

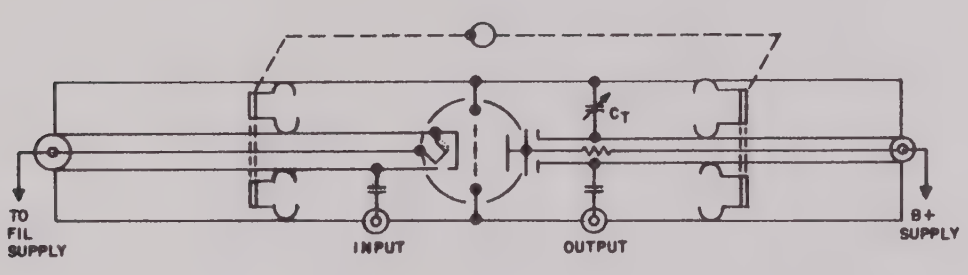


Figure 2-1 Preamplifier Schematic Diagram

The amplifier is built around a covered trough which acts as a resonant cavity, and upon which a coaxial triode is mounted. The shorter section of the cavity constitutes a 1/8 - wavelength coaxial line which couples the cathode input impedance to a 50-ohm line. The longer section (a shorted 1/4 - wavelength line) presents a high-impedance load to the triode plate. The tuning elements of both lines, consisting of fingerstock plungers, are mounted on a mechanical guidance system, and are synchronized at a 2:1 tuning ratio to maintain the proper relationship over the 3.3:1 frequency range.

Each stage operates as grounded grid, and input and output coupling are capacitive. A trimmer capacitor (CT in figure 2-1) electrically synchronizes the two ganged plate cirtuit tuners.

2-2 POWER SUPPLY

The power supply is shown schematically in figure 2-2.

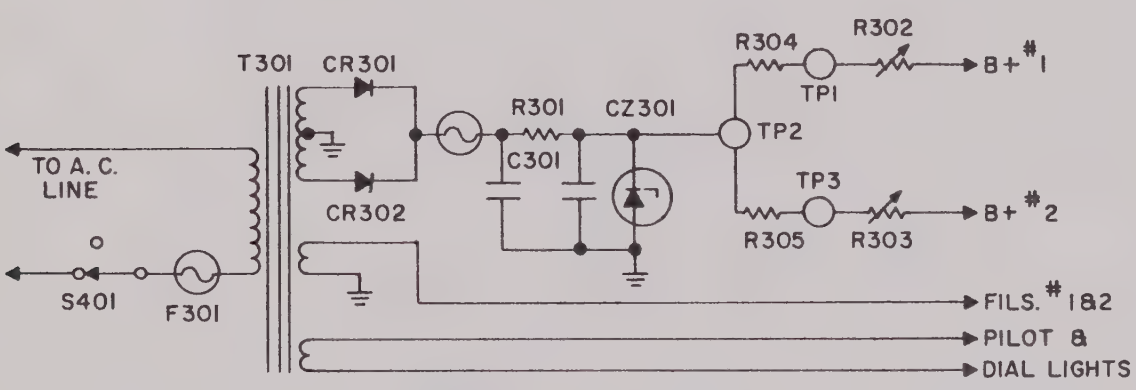


Figure 2-2 Power Supply Schematic Diagram

Power line voltage, (95-125 VAC, 60 cps) is applied to transformer T301 through S401, the power control switch located on the front panel. T301 transforms the line voltage to 400 VCT for rectification at CR301 and CR302, and to 6.3 VAC for filaments, pilot lights, and dial lights. Ripple filtering is provided by capacitor C301 and resistor R301. R301 also drops the rectified voltage to the CZ301 zener voltage regulator. Resistors R302 and R303 are used to adjust the plate current to the first and second amplifier stage respectively. When

R302 and R303 are adjusted for proper plate current (10 ma), the voltage across the voltmeter testpoints TP2 - TP1, and TP2 - TP3 (resistors R304 and R305 respectively) will measure 1.0 volt.

A schematic circuit of the two rf amplifier stages is shown in figure 2-3. The complete power supply circuit is shown in figure 2-4.

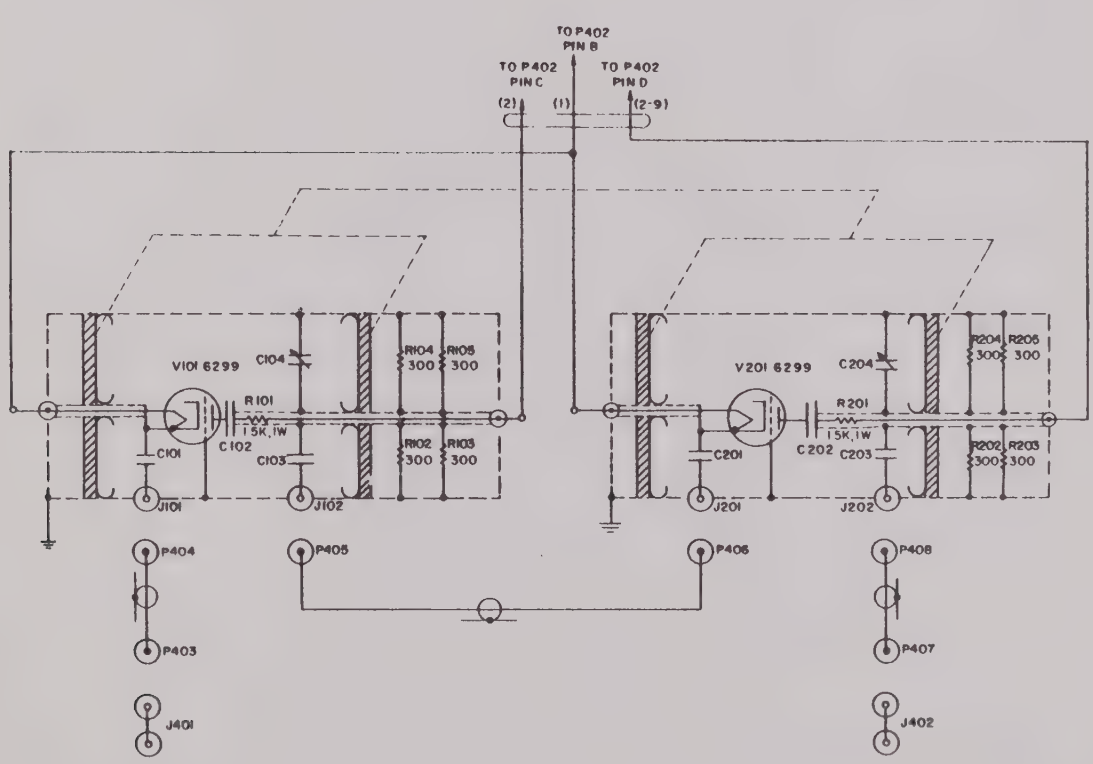


Figure 2-3 Complete Circuit, RF Stages, AP-502R Preamplifier

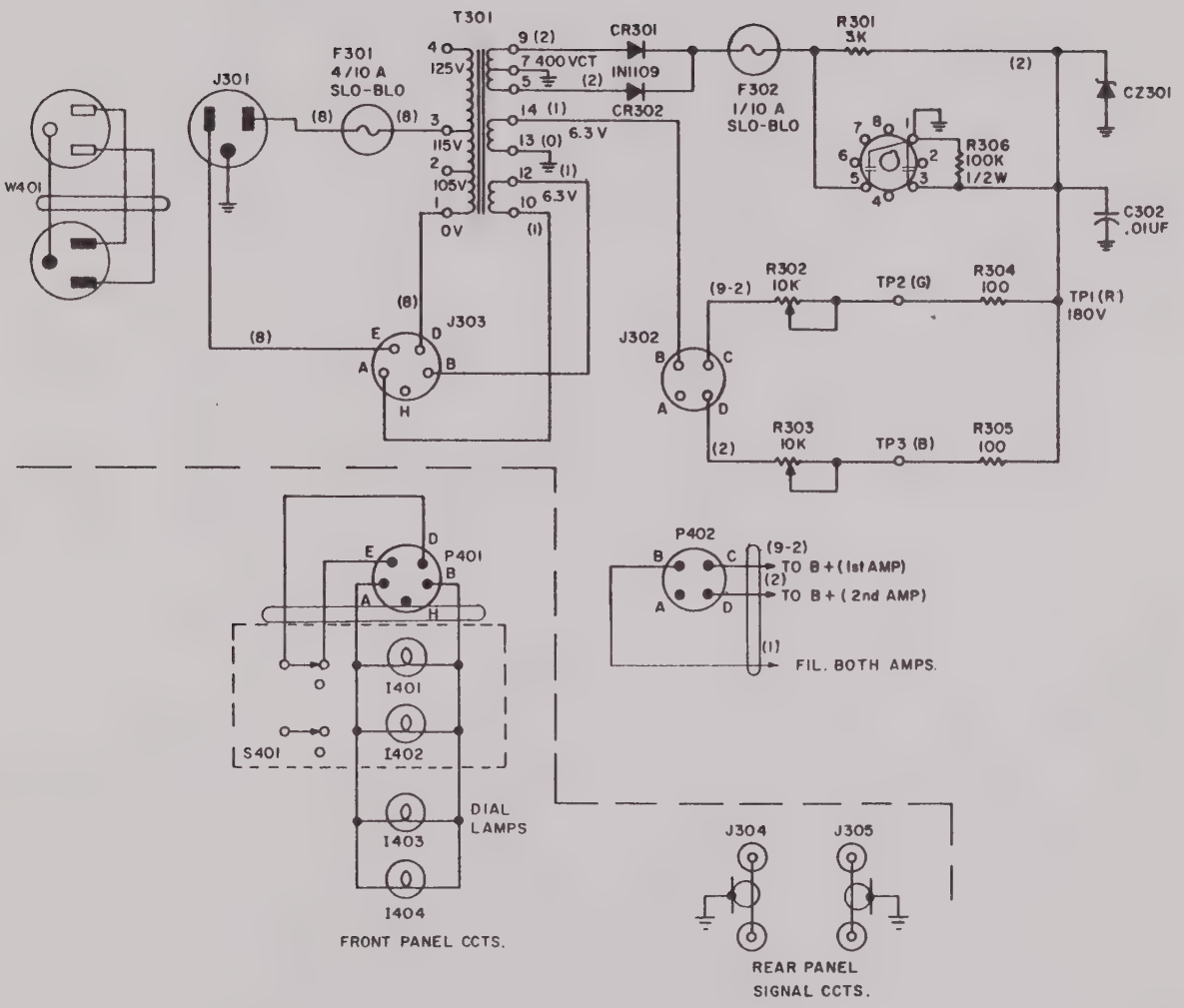


Figure 2-4 Complete Circuit, Power Supply, AP-502R Preamplifier

SECTION 3 - OPERATION

3-1 SIGNAL CONNECTIONS

The AP-502R Preamplifier has two sets of panel receptacles, one set on the front panel, and one set on the rear panel, so that signal connection may be made at either panel. Prior to installing the Preamplifier in an equipment rack, the most convenient arrangement should be decided upon and the internal cables connected accordingly. (Remove the Preamplifier dust cover to check the location of the input and output cables, and reconnect if necessary.)

3-2 POWER LINE VOLTAGE AND TRANSFORMER TAPS

Measure the line voltage and set the primary tap on the Preamplifier power transformer to the closest available voltage tap (105, 115 or 125 VAC) to insure proper operation of the vacuum tube filaments. (This tap is set to 115 VAC at the factory.) To change the primary tap, remove the dust cover, unsolder the grey lead from lug 3 of T301 and resolder this lead to lug 2 for 105 volts or lower, or to lug 4 for 125 volts or above. The preamplifier may be operated for short periods without making this adjustment, but caution must be observed; high filament voltage results in shortened tube life while excessively low voltage results in diminished gain and sensitivity.

After connecting the Preamplifier to a suitable power source,

pushing the POWER button on the front panel should result in illumination of the POWER button and dial lights.

3-3 INPUT PRECAUTIONS

Because the triode furnished with the AP-502R Preamplifier (type 6299) possess a zero grid current rating, operation near high-powered transmitters or other high-level signals can result in vacuum tube deterioration. If such operation cannot be avoided, it is recommended that the 6299 be replaced with type 7644.

3-4 TUNING

The tuning knob-and-shaft drives fingerstock plungers along a mechanical guidance system mounted over the resonant cavities to provide tuning by variation of the length of the coaxial lines. The frequency-reading dial and pointer mechanism is mechanically coupled to the drive shaft by a dial cable, capstan, and pulley arrangement.

SECTION 4 - MAINTENANCE DATA

4-1 DC ADJUSTMENTS

All dc test points and adjustment controls are located on the rear panel.

CAUTION NOTE: All Test Points are at B+ potential above chassis.

The adjustment procedure is as follows:

1. Insert the positive probe of a dc voltmeter into test point TP-1, and the negative probe into TP-2. Reading should be 1.0 volts (to indicate 10 ma. plate current). Adjust by turning R302.

2. Remove the negative probe from TP-2 and insert it into TP-3. Reading should be 1.0 volts. If not, adjust R303.

4-2 FREQUENCY AND GAIN ALIGNMENT

NOTE: Frequency and gain alignment should be preceded by dc Adjustments (Para. 4-1).

1. Remove the equipment dust cover.

2. Remove the three mounting screws holding each of the tuned line covers; slide the tuned line covers off the lines.

3. The frequency trimmer capacitors (C104 and C204) consist of small "L" tabs fastened to the center partition of the line by means of a screw. Loosen the fastening screws and reduce capacitance to a minimum by swinging the capacitor plate away from the tuned lines.

4. Connect the first preamplifier stage into the equipment

arrangement of figure 4-1.

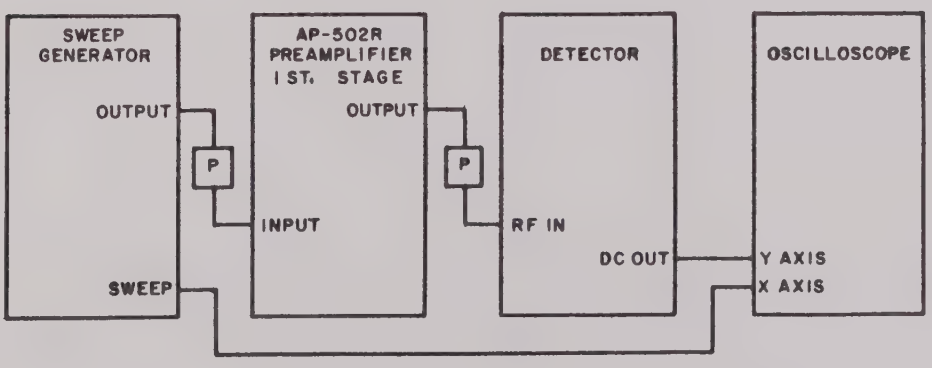
5. Replace the line cover and turn on the preamplifier.

6. Tune the sweep generator to 1000 mc center frequency and 30 mc sweep width.

7. Tune the Preamplifier to 1000 mc as indicated by the response peak on the oscilloscope. This is accomplished as follows:

a. With the tuning control knob tune the cathode to near maximum high frequency.

b. With the anode plunger assembly cable screws loose, manually position the anode plunger until a response peak is obtained at 1000 mc. Re-tighten the cable clamping screws.



P - Pad Attenuators
10 db, 50-ohm coaxial

Figure 4-1 Gain Alignment Arrangement

8. Now adjust the output coupling capacitor, C103, for maximum 1000 mc gain. Adjustments are made by bending the C103 plate that is attached to the stage output receptacle. As this capacitance is increased (the plate is positioned closer to the plate line) gain will decrease, bandwidth will increase, and the response peak will decrease in frequency. As the capacitance is decreased, gain will increase and bandwidth will decrease, until a point is reached where bandwidth ceases to decrease but gain starts to decrease. This is the correct setting of C104. For each adjustment change, the line cover must be removed. However, upon replacement of the line cover between adjustments, the mounting screws need not be replaced as long as the cover is held tightly against the center partitions. The adjusting tool should be plastic and, if power is left on during adjustments, care should be taken to prevent the shorting of B+ at the triode plate connector to the ground.

9. After the adjustment of step 10 has been optimized, replace the line cover and secure with mounting screws. Gradually decrease the Preamplifier frequency and follow the response peak with the sweep generator. There should be no abrupt gain, or bandwidth change, or indications of instability. The Preamplifier response should be reasonably uniform from 290 to 1010 mc. If the lower frequency limit cannot be reached, repeat steps 6 through 9 with the following exception: Adjust the anode plunger for a slightly higher starting point.

Then, secure the anode clamping screws.

10. Repeat steps 6 through 9 with the second Preamplifier stage connected into the test setup.

11. Replace the inter-stage cable.

12. Reconnect the equipment arrangement of figure 4-1, but with both Preamplifier stages in series.

13. Tune the sweep generator to 1000 mc and its sweep width to 30 mc.

14. Tune the Preamplifier to 1000 mc as indicated by the response pattern on the oscilloscope. If two response peaks are present, with one appearing at some frequency other than 1000 mc, set the lower frequency at 1000 mc. Determine which of the two stages is responding to the higher frequency and decrease its frequency by increasing C104 or C204. The latter can be accomplished by observing the individual stage response. Without changing the tuning, reconnect, temporarily, the test arrangement as shown in figure 4-1 and determine which stage is operating above 1000 mc. Then, reconnect both stages and increase the appropriate trimmer capacitor, tuning for maximum single-frequency 1000 mc gain. The same procedure applies if two separate peaks were not present at the outset, except that smaller increments of capacitance change will be required to peak the response curve.

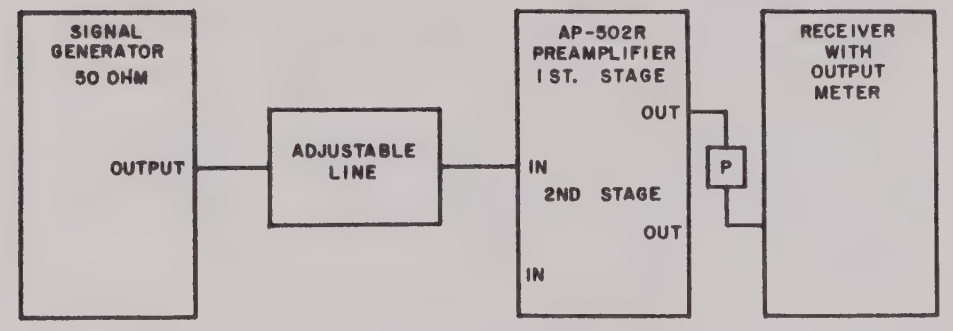
15. With the Amplifier tuned to 1010 mc check the position of the cathode plungers. They should be at their extreme high-frequency

limit of travel. To adjust, loosen the tuning cable connecting screws which fasten the plate plunger assembly to the tuning cables; loosen the setscrews which secure the shaft stops; then turn the tuning knob to position the cathode plungers to the msximum high-frequency limits. Set the shaft stops against the cathode plunger assembly and tighten the setscrew. Re-tighten the plate plunger cable fastener screws.

16. Return the Preamplifier and sweep generator to 1000 mc and reposition, if necessary, the tuning needle to coincide properly. The needle is repositioned by bending, with extreme care, the needle support rod. Restraighten the needle if necessary.

17. Gradually decrease the Preamplier frequency and follow the response peak with the sweep generator. If gain decreases at the low-frequency end of the tuning range without an accompanying increase in bandwidth, the capacity of the cathode coupling capacitors, C101 and C201, must be increased, by bending the input plates. The normal setting on the input capacitors is at, or near, the maximum value of capacitance. The optimum setting must be made while observing the voltage standing-wave ratio (VSWR) on the input. This may be performed at 3000 mc without upsetting 1000 mc operation. If VSWE at 1000 mc is high (1.2 or higher) it might be caused by excessive series inductance or improper synchronization of the cathode plungers. Any good VSWR measuring arrange-

ment may be used, but that shown in figure 4-2 is recommended.



P-Attenuator Pad
10 db, 50 ohm

Figure 4-2 VSWR and Gain Measurement

NOTE: When making the preceding frequency and gain alignments it is recommended that the instructions in Section 4-7, Mechanical Adjustments, be checked first to assure that the cable and dial mechanism is accurately adjusted.

4-3 VSWR MINIMIZATION AND GAIN MEASUREMENT

The VSWR minimization procedure is as follows:

1. Arrange and connect the test equipment as in figure 4-2.

2. Tune the Preamplifier, Receiver, and Signal Generator to 300 mc.

3. With the signal generator output at zero, adjust the receiver gain to obtain an apparent but negligible meter deflection (relative to full-scale deflection).

4. Increase the generator output for half-scale deflection.

5. Set the adjustable line for peak meter deflection.

6. Adjust the generator output for a convenient deflection (for example, 1 volt).

7. Reset the adjustable line for minimum meter deflection. If the ratio of the first to the second deflection is unity or only slightly higher (1.1 to 1), no readjustment of the Preamplifier input capacitor is necessary. If the ratio is higher, then the value of the input capacitor generally must be increased. In making capacitor adjustments, ascertain that the capacitor is not shorted to the cathode tuned line, etc.

8. If the ratio is high, check the cathode plunger fingerstock connection at the center rod and outside walls. To gauge the top row of fingerstock, turn the line cover upside down and lay it across the line partitions. Check for proper installation of the input capacitor plate. It must be connected to the input receptacle at or near its center point and

it must be parallel with the cathode capacitor plate. The setscrew in the cathode line support partition may be loosened and the line rotated to aid in adjusting the input capacitor.

9. Power gain measurement may be made employing the arrangement of figure 4-2, except that the two stages must be reconnected in series. This procedure may be followed for any frequency.

10. With the signal generator output set at zero, adjust the receiver gain to obtain apparent but negligible meter deflection caused by Preamplifier and receiver noise.

11. Increase the signal generator output for half-scale deflection of the meter, and note the signal generator microvolts output.

12. Bypass the Preamplifier by connecting the receiver pad input directly to the adjustable line output.

13. Increase the signal generator for half-scale deflection and note signal generator output. Power gain in db is then equal to 20 log of the ratio of this reading to that obtained in step 12. It is recommended that power gain be measured at both ends of the tuning range.

4-4 NOISE FIGURE MEASUREMENT

The Noise Figure of a receiving system, consisting of either a receiver only, or of a receiver preceded by a preamplifier, etc., may be measured by several different methods, the simplest of which employs a wideband noise source. (Simplest because accurate bandwidth measurements are not required.) Such measurements yield very useful information

concerning system sensitivity characteristics. If, however, attempts are made to evaluate the various system components (such as the preamplifier), by use of the following commonly employed relationship:

$$Fa = Fo - \frac{Fr}{Ga}$$

where Fa = Noise factor of preamplifier
Fo = Noise factor of preamplifier and receiver system
Fr = Noise factor of receiver alone, and
Ga = Power gain ratio of preamplifier,

then inaccuracies arise where there exists a great difference between Fa and Fr, or where the Fr/Ga ratio approaches Fo. Under these circumstances a proper evaluation of Fa cannot be obtained. Therefore, the noise figure measurement of the Preamplifier cannot be made unless either a sensitive receiver or sensitive, second, preamplifier-receiver combination is available. The following Noise Measurement Procedure assumes the latter case.

Noise Measurement Procedure:

1. Arrange and connect as in figure 4-3.

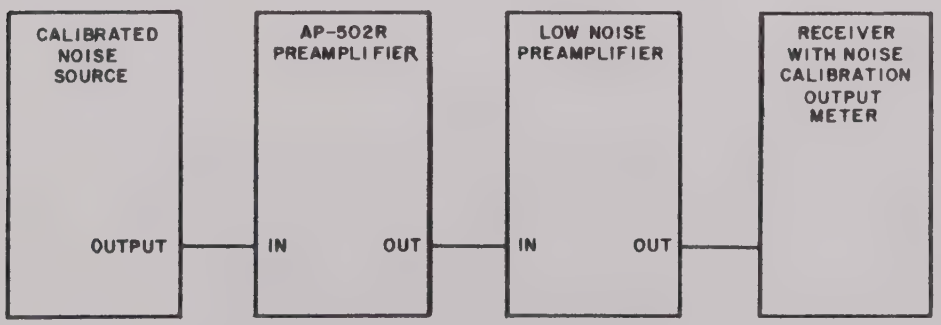


Figure 4-3 Preamplifier Noise Measurement

2. Tune both preamplifiers and the receiver to the desired frequency (300 mc, 600 mc and 1000 mc readings yield good indication of AP-502R performance).

3. If the receiver output meter was previously calibrated to noise waveforms the remainder of Step 3 may be omitted and the procedure resumed with Step 4. Otherwise,

a. With the noise source turned off, note if the receiver gain can be reduced from maximum to allow a convenient meter deflection (such as 1 to 10, etc.) preferably at from 1/3 to 1/2 of full scale. Otherwise, adjust the receiver gain to any integer and note for further reference.

b. Reduce the receiver gain.

c. Increase the noise source output to its maximum minus 3 db.

d. Adjust the receiver gain so as to produce the meter deflection decided upon in Step 3a.

e. Turn off the noise source and note if the receiver output drops substantially to zero. If the residual deflection is still high (more than 5% of the reference deflection) the meter calibration will be inaccurate and either the second preamplifier sensitivity or the receiver sensitivity must be improved in order to proceed.

f. Increase the noise source output to its maximum minus 3 db and note that the reference deflection is present.

g. Increase the noise source output to maximum and note the meter increase. The reference deflection and this 3 db meter increment will be used in subsequent measurements.

4. With the noise source output reduced to zero, adjust the receiver gain to provide a convenient reference deflection as from 1/3 to 1/2 of the full-scale reading (or to the reference deflection decided in Step 3a).

5. Increase the noise source output until the meter indicates a 3 db increase on receiver output, and note the noise source output, to obtain Fo.

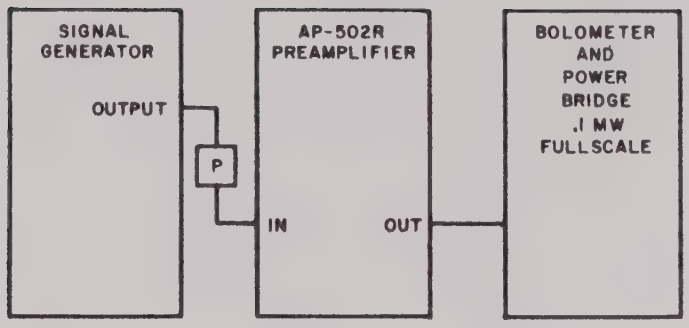
6. Disconnect the AP-502R Preamplifier and connect the noise source directly to the second preamplifier input.

7. Repeat Steps 4 and 5 to obtain Fr.

8. After converting all db figures to power ratios, the preamplifier noise factor may be calculated using the formula given at the beginning of this sub-section (4-4), together with the preamplifier power gain as measured in Section 4-2.

4-5 BANDWIDTH MEASUREMENTS

The following Bandwidth Measurement procedure requires the use of a signal generator of constant output level-versus-frequency for a frequency range of at least 15 mc together with a sensitive, calibrated, linear broadband detector such as bolometer. The procedure is as follows:



P - Attenuator Pad, 10 db, 50 ohm, coaxial

Figure 4-4 Bandwidth Measurement

1. With the equipment arranged and connected as in figure 4-4, tune the preamplifier and signal generator to the test frequency (300, 600 and 1000 mc for AP-502R tests) using the power bridge meter as a synchronization indicator.

2. Adjust the signal generator for a 0.1-milliwatt output (or the lowest full-scale value, whichever is less.)

3. Reduce the signal generator frequency for a 3 db decrease at the meter. Note this frequency.

4. Resume the signal generator for full-scale meter reading.

5. Increase the signal generator frequency for a 3 db decrease in the meter reading. Note this frequency. The Preamplifier bandwidth is the reading obtained in Step 4 minus that of Step 3.

4-6 TUBE REMOVAL AND REPLACEMENT

The vacuum tube replacement procedure is as follows:

1. Remove the equipment dust cover.

2. Tune the preamplifier to center scale.

3. Remove the three screws holding each line cover, and slide the line cover lengthwise off the line base trough.

4. Loosen the setscrew holding the cathode center conductor at the cathode end partition (the same threaded hole that fastens the cover).

5. Grasp the cathode line center conductor and slide it away from the vacuum tube, being careful not to strike the plunger fingerstock.

6. Loosen the two screws holding the grid-ring hold-down clip. Slide the clip up and lift it out.

7. Loosen the setscrew at the anode pin and slide the vacuum tube in the cathode direction.

8. Replace vacuum tube in opposite sequence, and remake all adjustments of Section 4, if necessary.

4-7 MECHANICAL ADJUSTMENTS

Mechanical adjustments requiring other than restringing, adjusting tuning drive clutch tension, or replacing tubes should not be attempted by the user but referred to the manufacturer.

1. Drive Cable Stringing

Each drive cable is one continuous length, assembled to the drive and idler mechanism in accordance with figure 4-5. Recommended string procedure is as follows:

a. Secure one end of the cable to the anchor post.

b. String the cable around the outside cathode pulley, that is, the one farthest from the center of the chassis.

c. String the cable around the idler pulley at the anode end of the chassis.

d. Pass the cable between the two flat washers under the screw on the anode plunger assembly. Do not tighten this screw at this time.

e. String the cable around the main drive capstan into the threads, making two full turns.

f. String the cable around the idler pulley at the cathode end of the chassis.

g. String the cable around the inside pulley on the cathode plunger assembly.

h. Pass the cable between the two flat washers under the

screw in the end of the guide rod at the cathode end of the chassis, maintaining slight cable tension during wrapping.

i. Cable tension is increased by loosening the anchor post hold-down screw, turning the anchor post with a 1/4-inch open-end wrench, and retightening the hold-down screw.

j. String the other side, if necessary, in similar fashion.

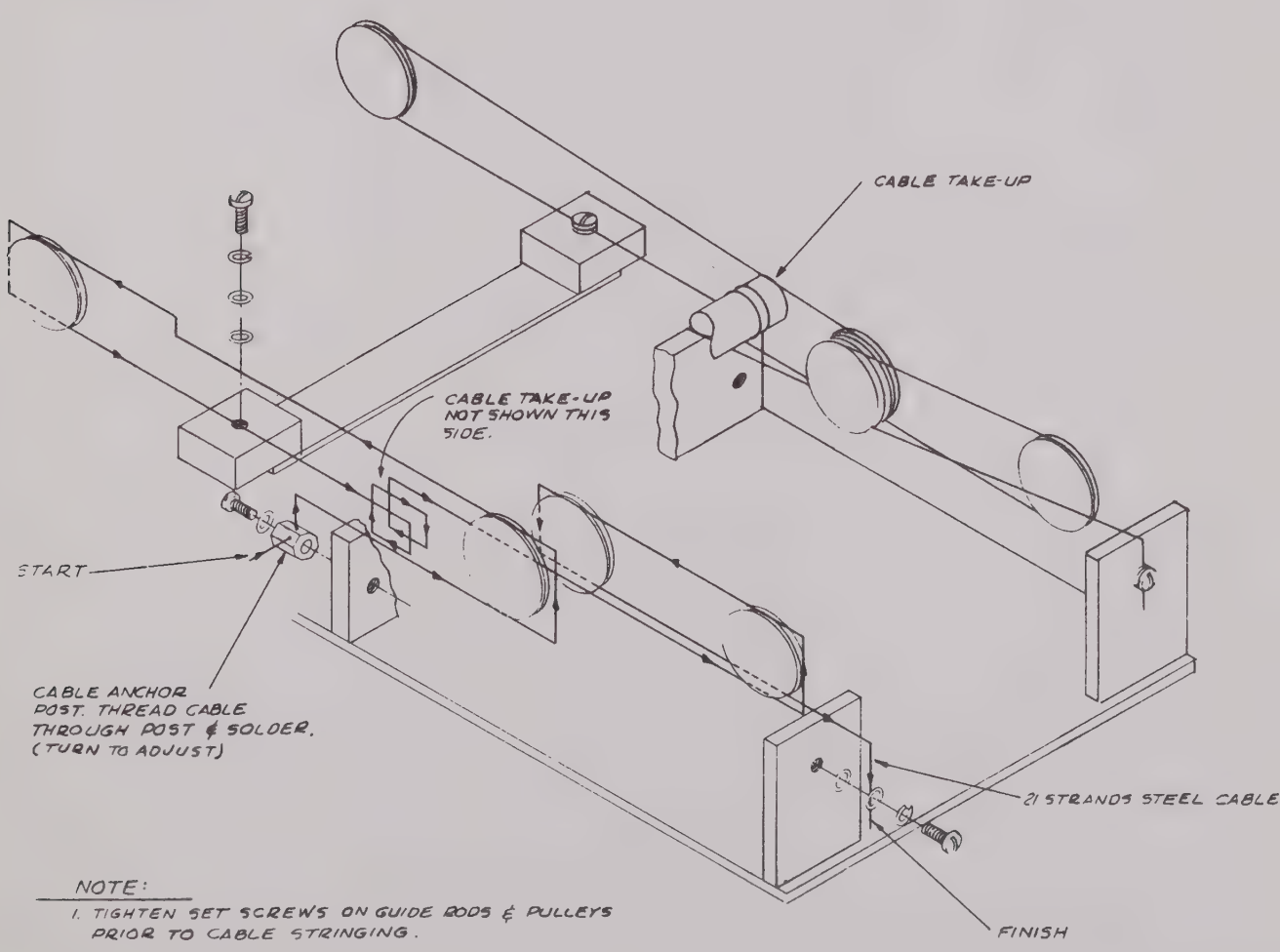

CABLE TAKE-UP
CABLE TAKE-UP NOT SHOWN THIS SIDE.
START
CABLE ANCHOR POST. THREAD CABLE THROUGH POST & SOLDER. (TURN TO ADJUST)
21 STRANDS STEEL CABLE
FINISH
NOTE:
1. TIGHTEN SET SCREWS ON GUIDE RODS & PULLEYS PRIOR TO CABLE STRINGING.

Figure 4-5 Drive Cable Diagram

k. With both cables strung and slight but equal tension on both cables (this can best be determined by plucking the cables and listening for equal tones), turn the tuning knob from one extreme to the other, noting the position of the cable on the capstans. The cable should, of course, not run off either end, and the cables stretched between the main drive capstan, cathode plunger assembly, and cathode idler should not rub with the cathode plunger assembly moving from one extreme to the other. This condition can be obtained by correctly positioning the two turns of cable on the main drive capstans.

2. Drive Cable Tension adjustments

a. Turn the tuning knob back and forth and note the slack in the cable, especially at the capstan as the direction is reversed. With the anode plunger assembly still not secured to the cable, tighten the cable tension again, as described in 1-i above.

b. Move the cathode plunger assembly by turning the knob to the high-frequency end. Manually slide the anode plunger assembly to its high-frequency end. Now, secure the drive cables between the two flat washers on each end of the anode plunger assembly.

c. Once again turn the tuning knob from one extreme to the other, noting any slack appearing in cable.

d. If additional adjustment of cable tension is necessary, always loosen two cable hold-down screws on the anode plunger assembly while tension is being changed; then re-tighten.

3. Tuning limit stops

Tuning limit stops are provided on the cathode plunger assembly guide rods. Stops are positioned as desired and fastened with setscrews.

4. Main drive clutch adjustment

The main tuning drive is provided with an adjustable slip clutch so as to prevent damage to cables and tuned lines.

a. The proper adjustment is achieved when the clutch slips only when the cathode plunger assembly comes against the stops on the guide rods in both high- and low-frequency limits.

5. After completing any of the mechanical adjustments as outlined above, refer to Paragraph 4-2 for frequency and bandwidth alignment.

4-8 AP-502R Parts List

Circuit Symbol Number	Description	Manufacturers Part No.
C301	Capacitor, Electrolytic Octal plug-in 2 x 40 MF, 450V	Aerovox AEP 88J
CD401	Power Cord	Belden 17460-S
CR301-303	Rectifiers, Silicon	Sarkes-Tarzian, 1N1109
CZ401	Diode, Zener	Hoffman 1N1814
I401	Pilot Bulb 6v, T 1-3/4 bulb, supplied p/o S401	Type 342 or 1768
I402	Same as I401	
I403	Pilot Bulb	Type 47
I404	Same as I403	
F301	Fuse, glass cartridge 4/10a, 250V, Slo-blo	Buss MDL 4/10
F302	Fuse, glass cartridge, 1/10a, 250V, Slo-blo	Buss MDL 1/10
J101	Coaxial Receptacle	Amphenol UG 1094/U
J102	Same as J101	
J201	Same as J101	
J202	Same as J101	
J301	Receptacle, 5 cct	Amphenol 126-218
J302	Receptacle, 4 cct	Amphenol 126-215
J303	Receptacle, 3 cct	Amphenol 160-5
J401	Coaxial Receptacle	Amphenol UG 490 A/U
J402	Same as J401	
J403	Same as J401	
J404	Same as J401	
P401	Connector, 5 cct	Amphenol 126-217
P402	Connector, 4 cct	Amphenol 126-214
P403	Connector, Coaxial	Amphenol UG 88C/U
P404	Same as P403	

AP-502R Parts List

Circuit Symbol Number	Description	Manufacturers Part No.
P405	Same as P403	
P406	Same as P403	
P407	Same as P403	
P408	Same as P403	
R101	Resistor, cc, 1500, 1w, 5%	
R102	Resistor, cc, 300 ohms	
R103	Same as R102	
R104	Same as R102	
R105	Same as R102	
R201	Same as R101	
R202	Same as R102	
R203	Same as R102	
R204	Same as R102	
R205	Same as R102	
R301	Resistor, WW, 3000 ohms 25W, 1%	Daleohm RA-25
R302	Potentiometer, CC, 10K ohm, 2W, w/locking nut	Ohmite CLU 1031
R303	Same as R302	
R304	Resistor, CC, 100 ohms 1/2W, 5%	
R305	Same as R304	
R306	Resistor, CC, 100 K Ohm 1/2W, 5%	
S401	Power Switch, DPDT, w/Barriers, & Lense (Red)	C6.57 R22 Controls Co. America
T301	Transformer, Power primary: 105, 115, 175V, 54-66cps, second: 200 or 400 VRMS-CT, 070a., 6.3V, 3a, and 6.3V., 2a.	UTC N-593A
V101	Vacuum Tube	GE-6299
V201	Same as V101	
XC301	Octal, socker, ceramic	Elco 338-PHSPTD

AP-502R Parts List

Circuit Symbol Number	Description	Manufacturers Part No.
XCR301	Fuse Clips, w/solder lug	Littlefuse 121004
XCR302	Same as XCR301	
XV101	Receptacle, BNC	Amphenol UG-680/U
XV201	Same as XV101	
XF301	Fuse holders	Buss HKP
XF302	Same as XF301	
XTP1	Tip Jack (red, green, and blue respectively)	H.H. Smith 1501-102, 1501-104, 1501-105 respectively
XTP2	Same as XTP1	
XTP3	Same as XTP1	
XI403	Pilot light holder	Dialco 705
XI404	Same as XI403	
Tuning	Knob	Raytheon 175-102G
Handles	Oval, black oxide finish (modified	USECO 1017-14
Handles	Round, black oxide finish	
Gear	Sterling Precision	S-22N-72
Gear hub	Sterling Precision	E62-6

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